

CRYENGINE® 3

CRYYSIS® 3

# The Art and Technology behind Crysis 3

# PRESENTERS

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# PLAN

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Introduction to Crysis

Art pre-production

Art guidelines

Art production overview

Technology overview

Hybrid deferred rendering

# CRYYSIS FRANCHISE

First Person Shooter

Super soldier equipped with a Nanosuit

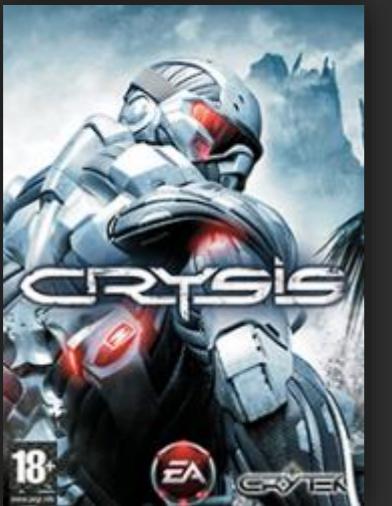
Sandbox gameplay

Crysis trilogy

Crysis 1 (2007): awakening of an ancient alien civilization on an island

Crysis 2 (2011): fighting against the alien invasion in New York

Crysis 3 (2013): awakening and destruction of the alien boss in New York



# CRYENGINE

Dozen years of development

“Real-time all the time”

Multiplatform engine

Licensees

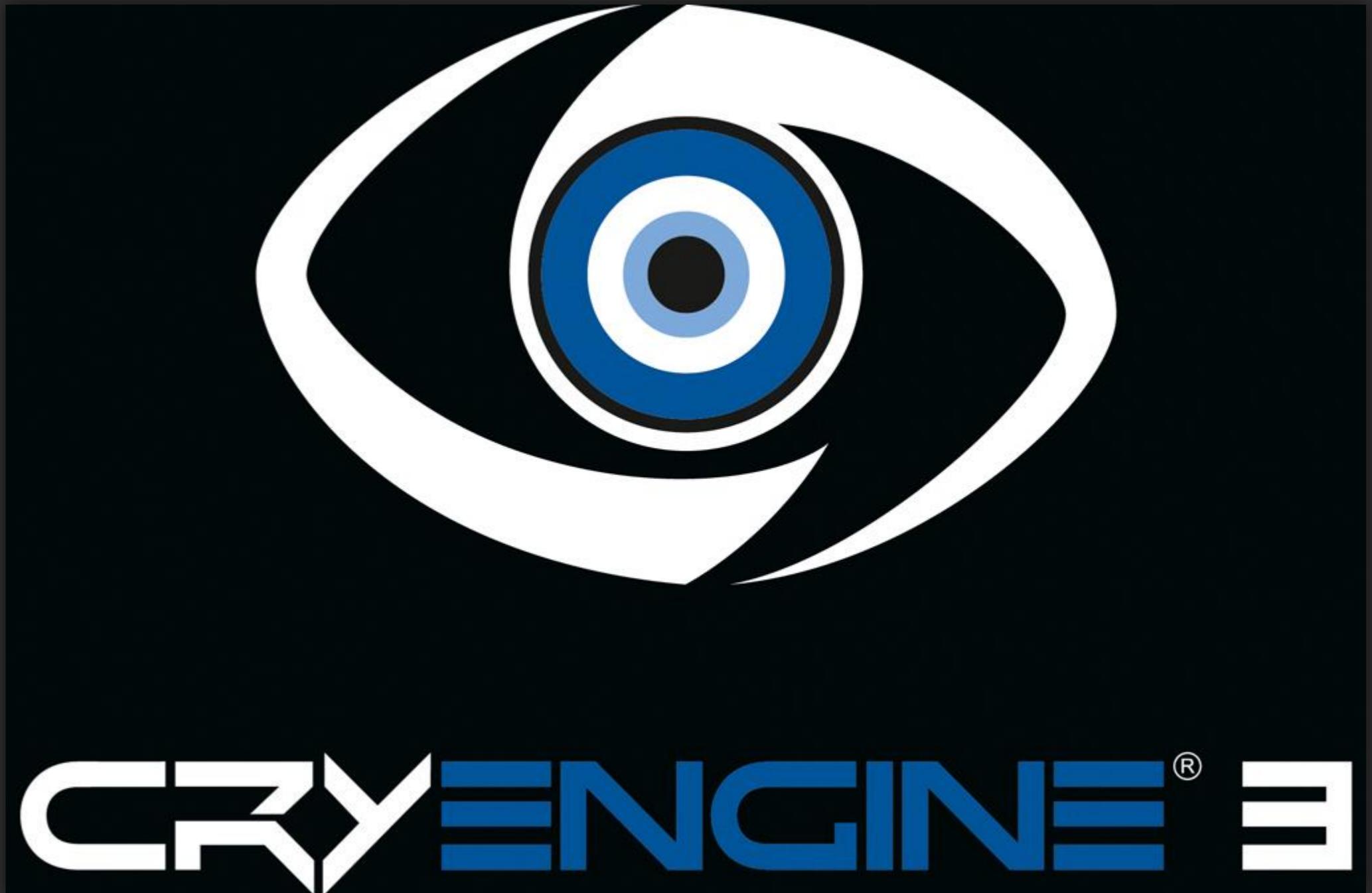
Sniper Ghost Warrior 2 (City Interactive)

MechWarrior Online (Piranha Games)

Monster Hunter Online (Tencent, Capcom)

Star Citizen (Cloud Imperium Games Corporation)

etc.



# OBJECTIVES FOR CRYYSIS 3

Merge the best of Crysis 1 and 2

More open levels

More gameplay freedom

More variety

More weapons (bow and alien weapons)

Push the visual quality even further with CryENGINE 3

Set a benchmark for next generation games



# INITIAL CONSTRAINTS

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Smaller (but very experienced) development team

Some developpers re-assigned to Ryse and Homefront 2 after Crysis 2 production

~150 people on Crysis 2

~100 people on Crysis 3

Handful of graphics programmers

Tiny art team (dozens of environment artists, couple of level artists, 1 lighting artist & 1 FX artist for the single player campaign)

Shorter production time

38 months for Crysis 2

23 months for Crysis 3

Create a better game

Art bottleneck

No place for mistakes

# CONCEPT ART

Main themes

Rain forest

Manhattan, New York

Dome

Handful of concept artists

New environments

New main characters

New design for human enemies

New aliens and weapons



# CONCEPT ART

## Crysis 1 meets Crysis 2

Strong natural settings

Extremely dense vegetation

Urban environment with destruction

Bigger levels (more impressive vistas)







# ART BENCHMARK\ OBJECTIVES

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Create a pre-production art-focused level representative of the game (end of 2011)

Implement the vision of the art direction

Dense jungle

Overgrown buildings (destruction, rust, moss, etc.)

Rivers

Dappled lighting

Improve the art pipeline and workflow

Create a good stress test for low-end hardware (consoles)

Keep the art department busy

~2 months production



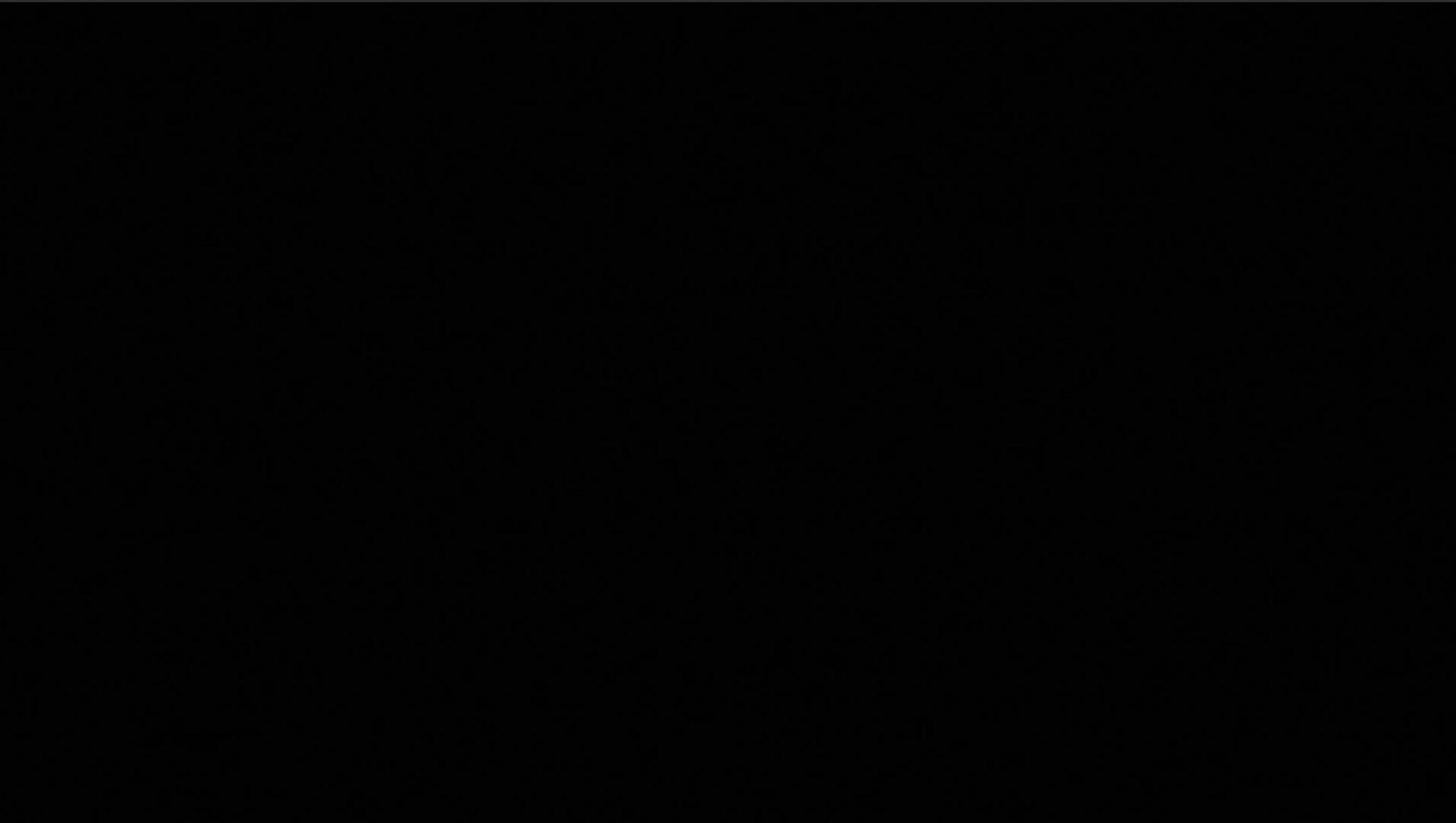








# ART BENCHMARK\VIDEO



# POST ART BENCHMARK

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Throw away most of Crysis 2's environment assets

- Inconsistent with the art style (pristine assets)

- Not detailed enough (geometries and textures)

Rebuild all environment assets

- Geometries: add more destruction

- Textures: overgrown style (rust, moss, etc.)

- Materials: wet look

# POST ART BENCHMARK

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## Create art guidelines

Make sure all artists follow the same rules for textures and materials

Art resources located in Frankfurt, Nottingham, Kiev and a few outsourcing studios

## Re-calibrate the lighting engine

## Create a test level for artists

# MONITORS

Ensure all artists work with proper monitors (IPS, \*VA or PLS panels)

Calibrate all monitors to industry standards (sRGB, Gamma 2.2, 6500K and ~100cd/m<sup>2</sup>)

View angles of low end monitors (TN panels)



View angles of higher end monitors (IPS panel)



Images credit: [www.anandtech.com](http://www.anandtech.com)

# TEXTURES\SELECTION

Minimize lighting information in the textures

Prevent direct light (harsh and dark shadows)

Ensure neutral color balance

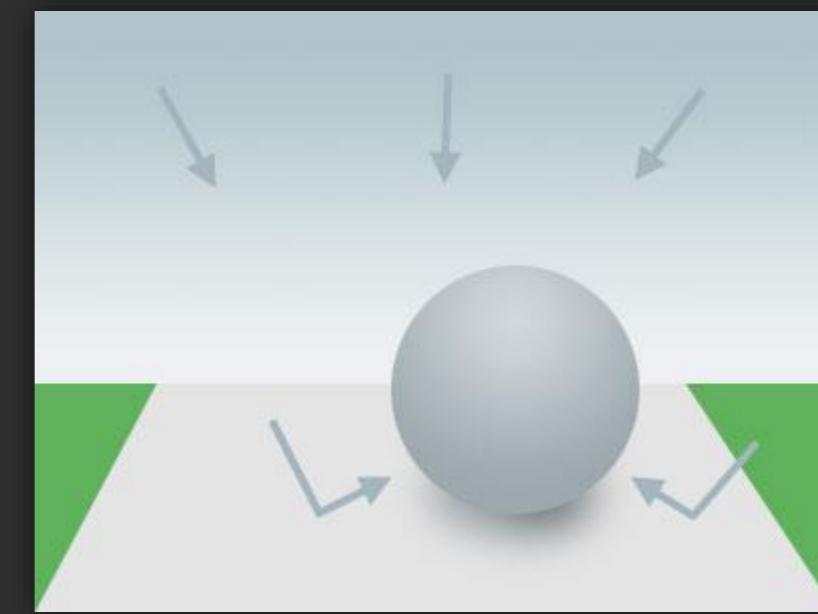
Use overcast lighting for smooth ambient lighting



Bright daylight



Low sun settings



Overcast

Images credit: Richard Yot, [www.itchy-animation.co.uk](http://www.itchy-animation.co.uk)

# TEXTURES \ COLOR AND LUMINANCE CONTROL

## Kodak Color Control Patches

Ideal for non-studio lighting

Place them close to the photographed subject

Correct the RGB curves in Photoshop

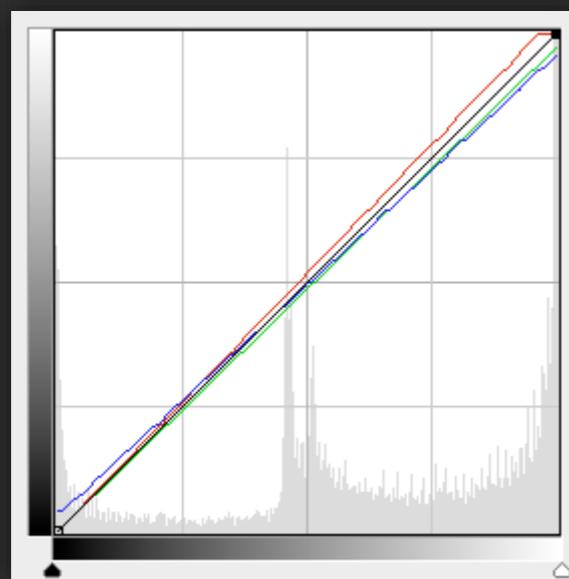


Image credit: [www.kodak.com](http://www.kodak.com)

# DIFFUSE TEXTURES\COMMON MISTAKES

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## Common mistakes of artists

Too much AO baking

Overly dark cavities

Dark outlines

Too much contrast

## The engine will do it!

Self-shadowing: shadowmaps

Ambient occlusion: SSDO

Contrast: PostFX (eye adaptation, tonemapping, film curve and LUT colorgrading)

## Old generation engines still need a lot of baking (textures, vertex colors, etc.)

# DIFFUSE TEXTURES \ PRACTICAL EXAMPLE

Remove highlights and shadows (Shadows/Highlights adjustment in Photoshop)

Prevent the "triple darkening" (shadowmaps, SSDO and PostFX) leading to a cartoony look

Keep the color component only

"The flatter the better"



Reference diffuse texture (bad)

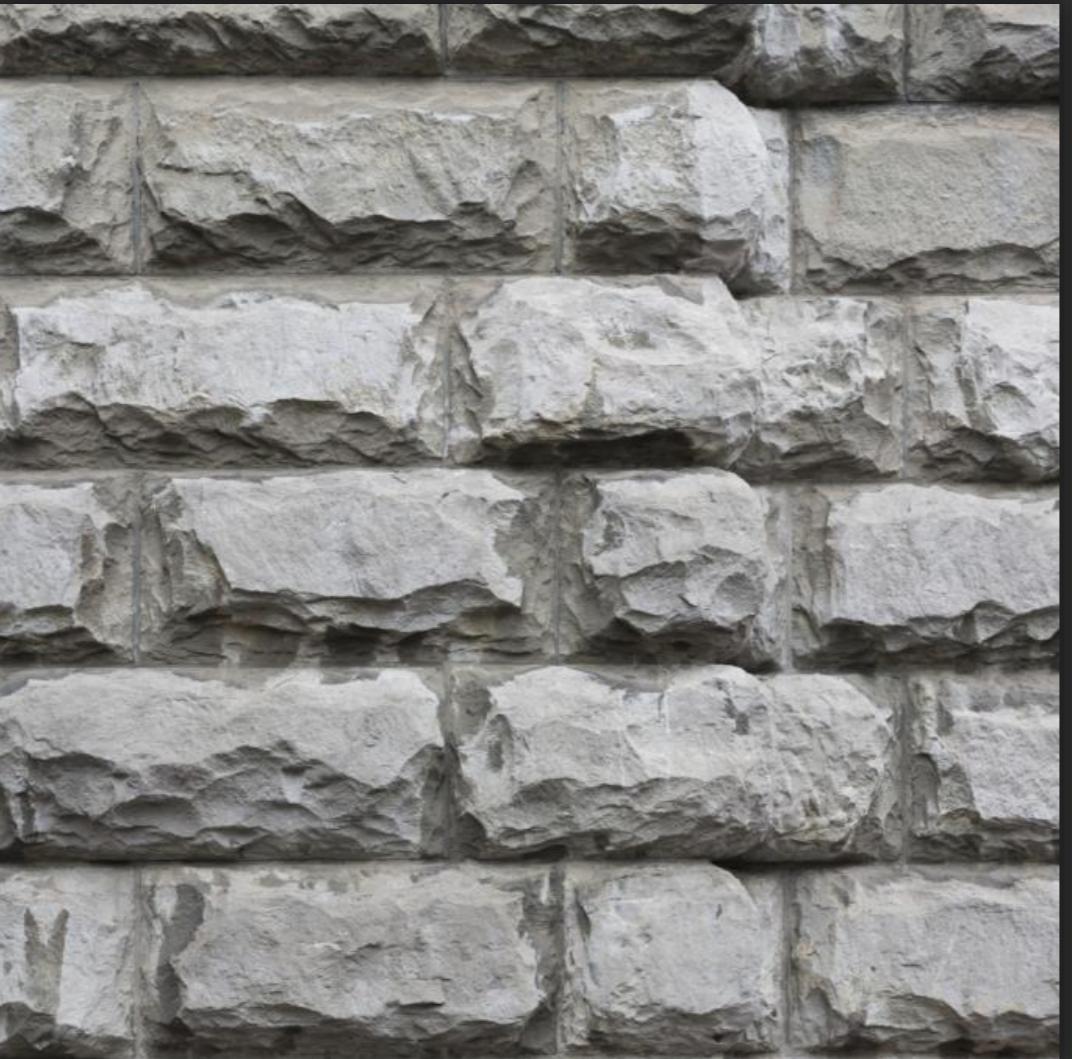


Modified diffuse texture (better)

# SPECULAR TEXTURES \ COMMON MISTAKES

Every artist has a different way of creating specular textures

Basic mistake: specular texture created from a high contrast gray-scaled diffuse texture



Diffuse texture



Diffuse-based specular (bad)

# PHYSICALLY-BASED SPECULAR

Value depends on the atomic structure of the surface, not on the glossiness (roughness)

For instance glossy and matte plastics have theoretically the same specular color

Glossiness specified with dedicated glossiness texture

Specular luminance [0;255]

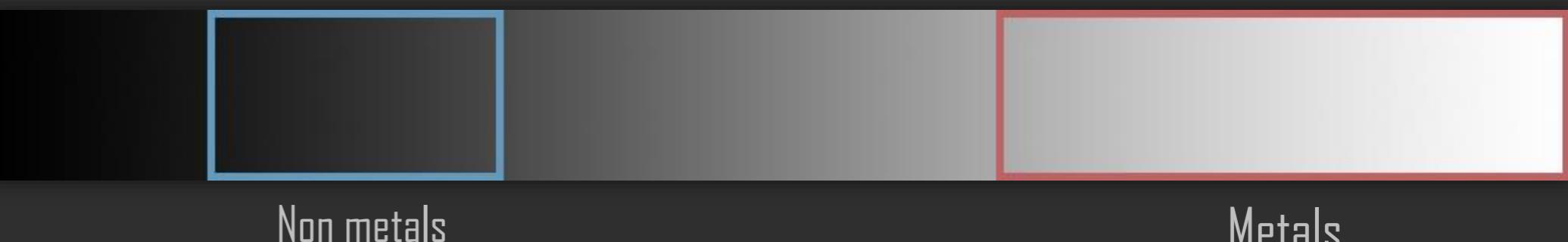
Most non metals: 30-70 (including rust)

Metals: +180

Specular color

Non metals: greyscaled

Metal: slightly colored (gold, copper, nickel)



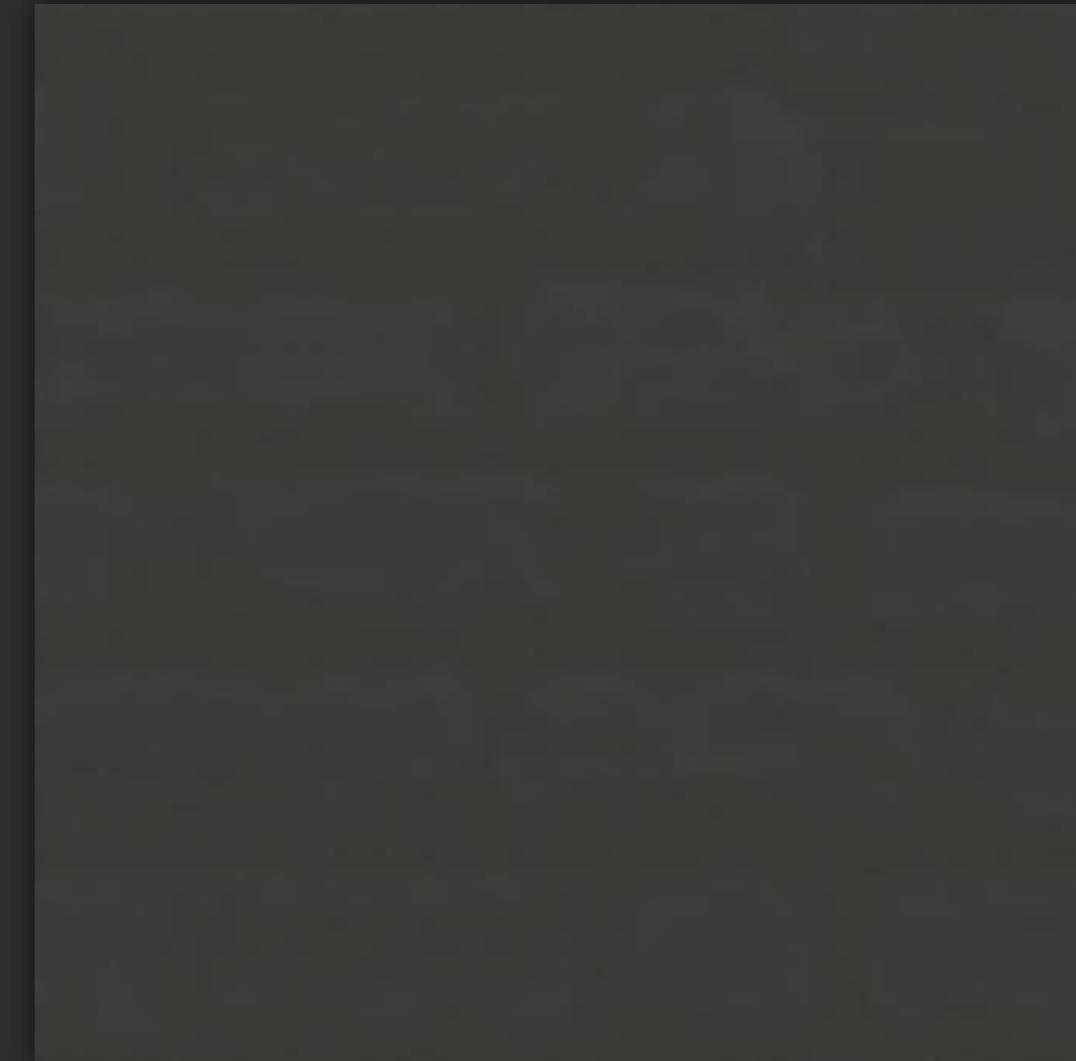
# PHYSICALLY-BASED SPECULAR \ PRACTICAL EXAMPLE

Average specular luminance of stone around 55

No real need for specular textures anymore (flat color)



Specular texture (bad)



Physically-based specular (better)

# GLOSSINESS

Roughness of the surface

Range from 0 to 255

Matte and rough materials: low glossiness

Glossy/polished/wet materials: high glossiness

Perfect mirror: 255

Glossiness range



# GLOSSINESS RANGE



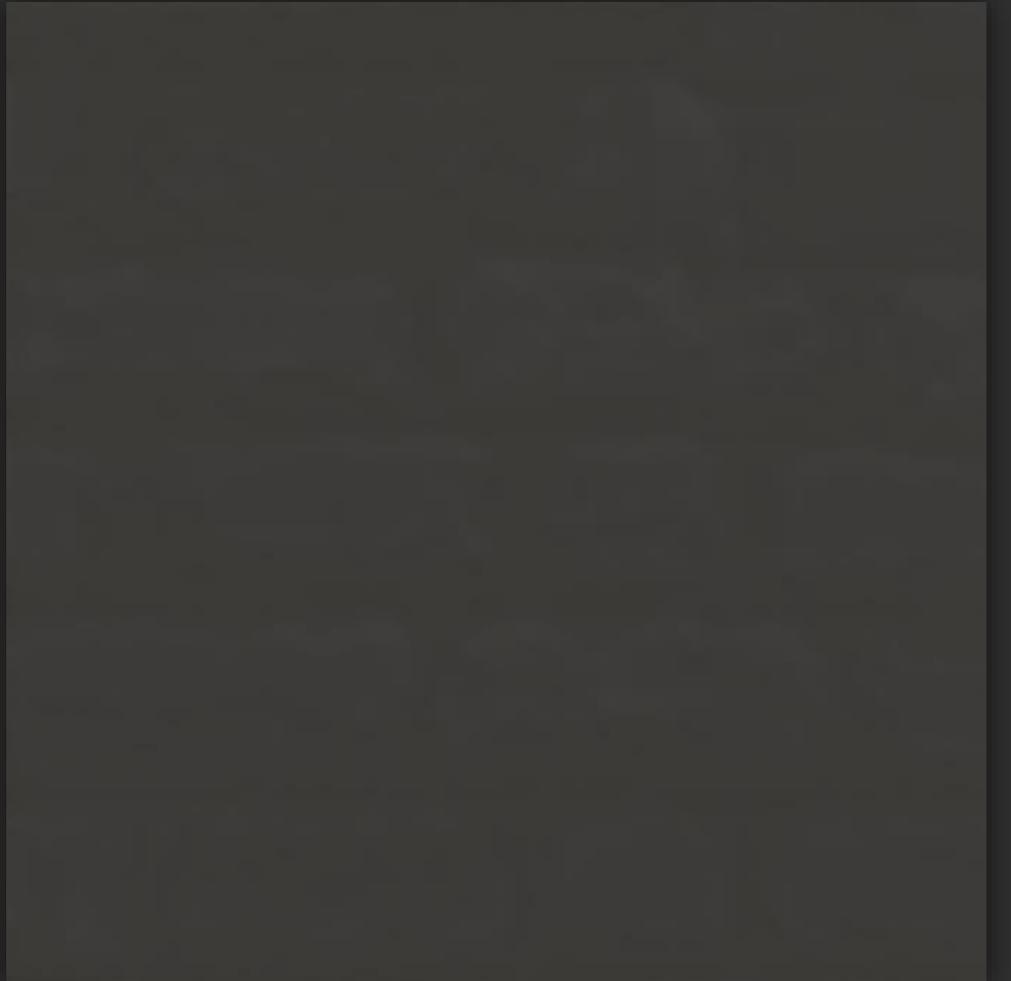
# GLOSSINESS TEXTURES

Roughness defined by a glossiness textures

Very important for material definition

More freedom for painting interesting details (scratches, speckles, wet areas, etc.)

Specular texture



Glossiness texture



# ASSET ZOO LEVEL

Create a test level for proof checking assets

Level based on the Art Benchmark

Store all assets in one single level

Check assets consistency at a glimpse

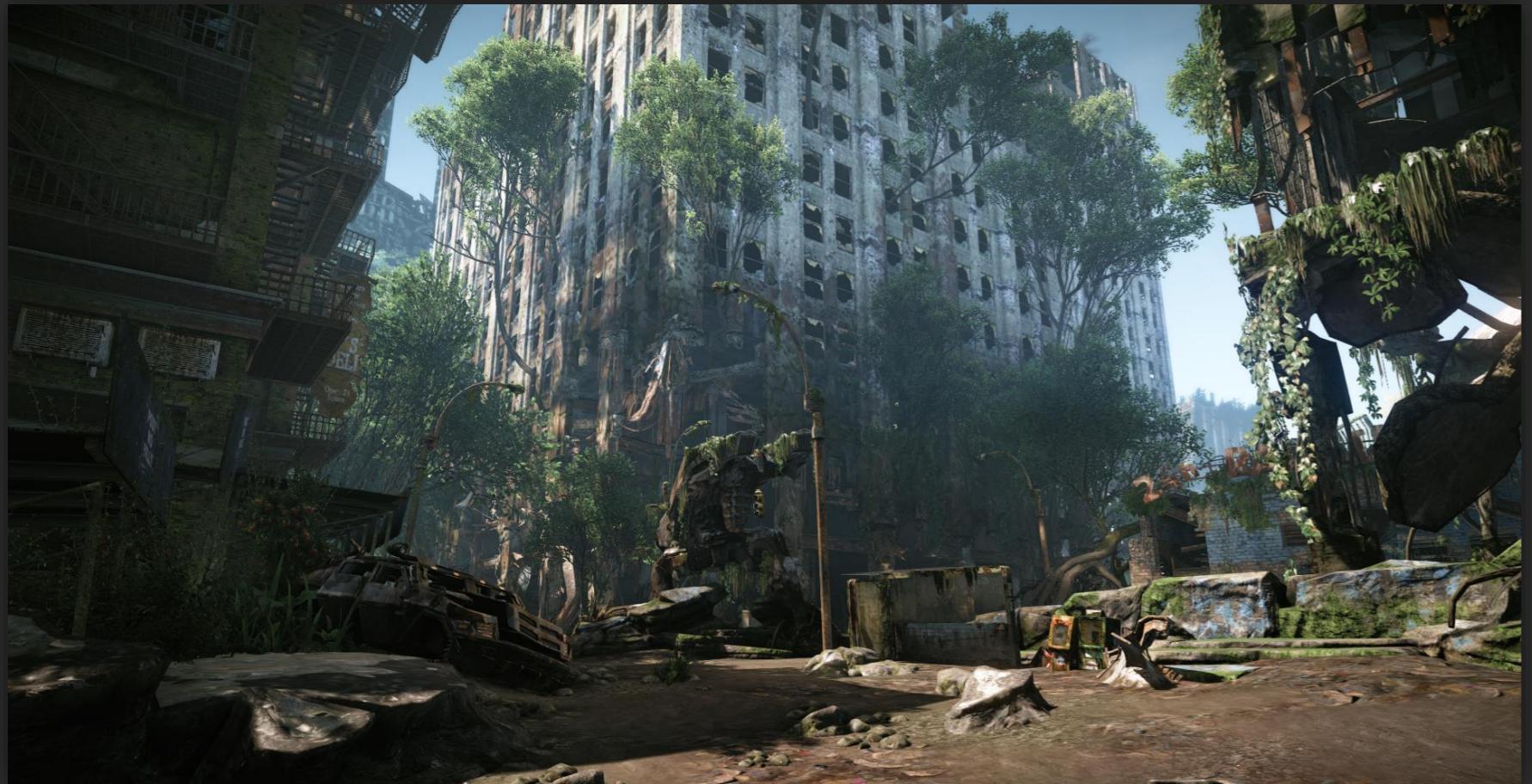


# ASSET ZOO LEVEL\FLAT SHADING

Pure flat indirect lighting

No post processing, no reflection, no ambient occlusion, no fog

Control the consistency of the diffuse textures



Standard lighting mode



Flat shading mode

# ASSET ZOO LEVEL\CLIPPING CONTROL

Visualize blacks and whites clipping

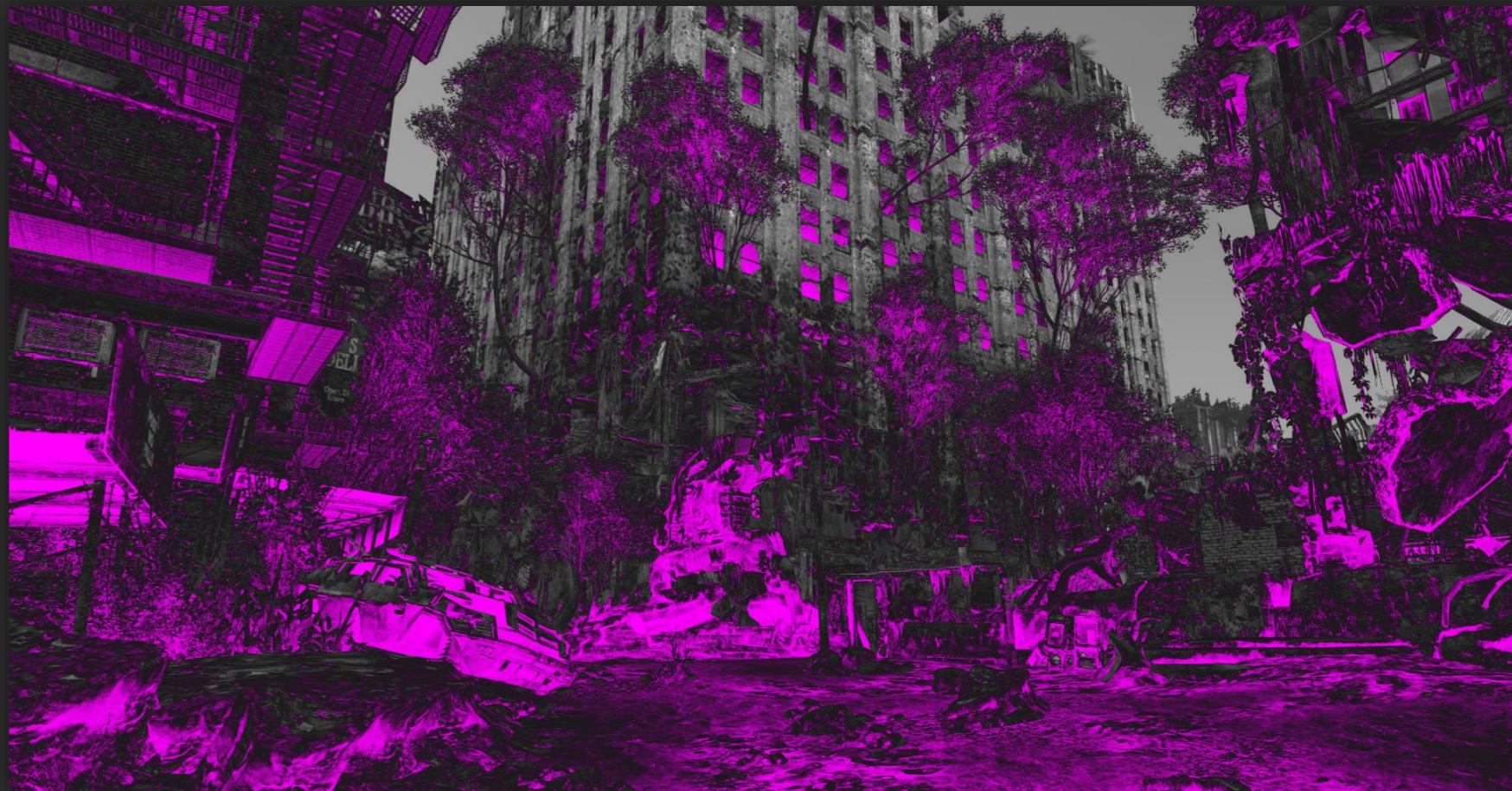
Black: RGB 0-15 (pink)

White: RGB 240-255 (green)

Good estimation of clipping on TVs with limited color space (16-235)

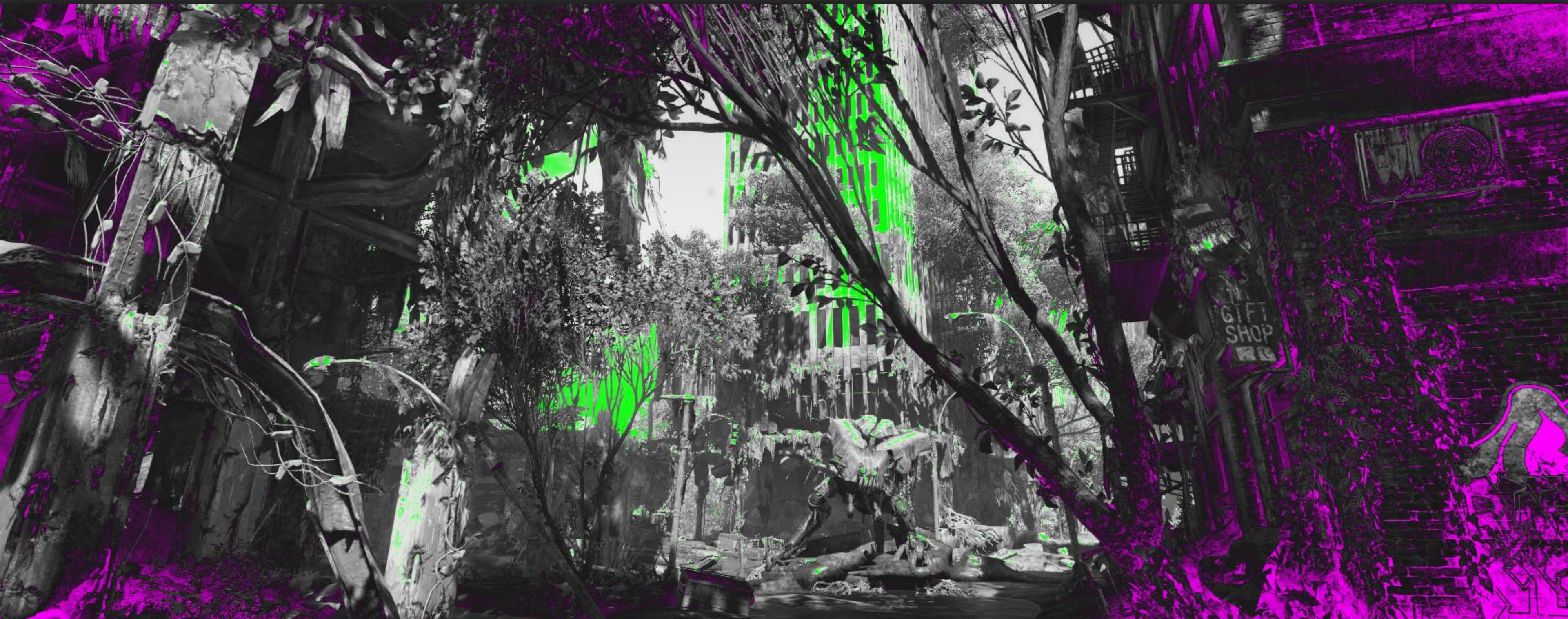


Flat shading mode



Clipping control mode

## ASSET ZOO LEVEL \ CLIPPING CONTROL



# REFERENCE MATERIALS

Creation of reference material for proof checking

Based on the most representative materials of the Art Benchmark

Artists compare their new textures with these reference materials

Lighting calibration based on these materials



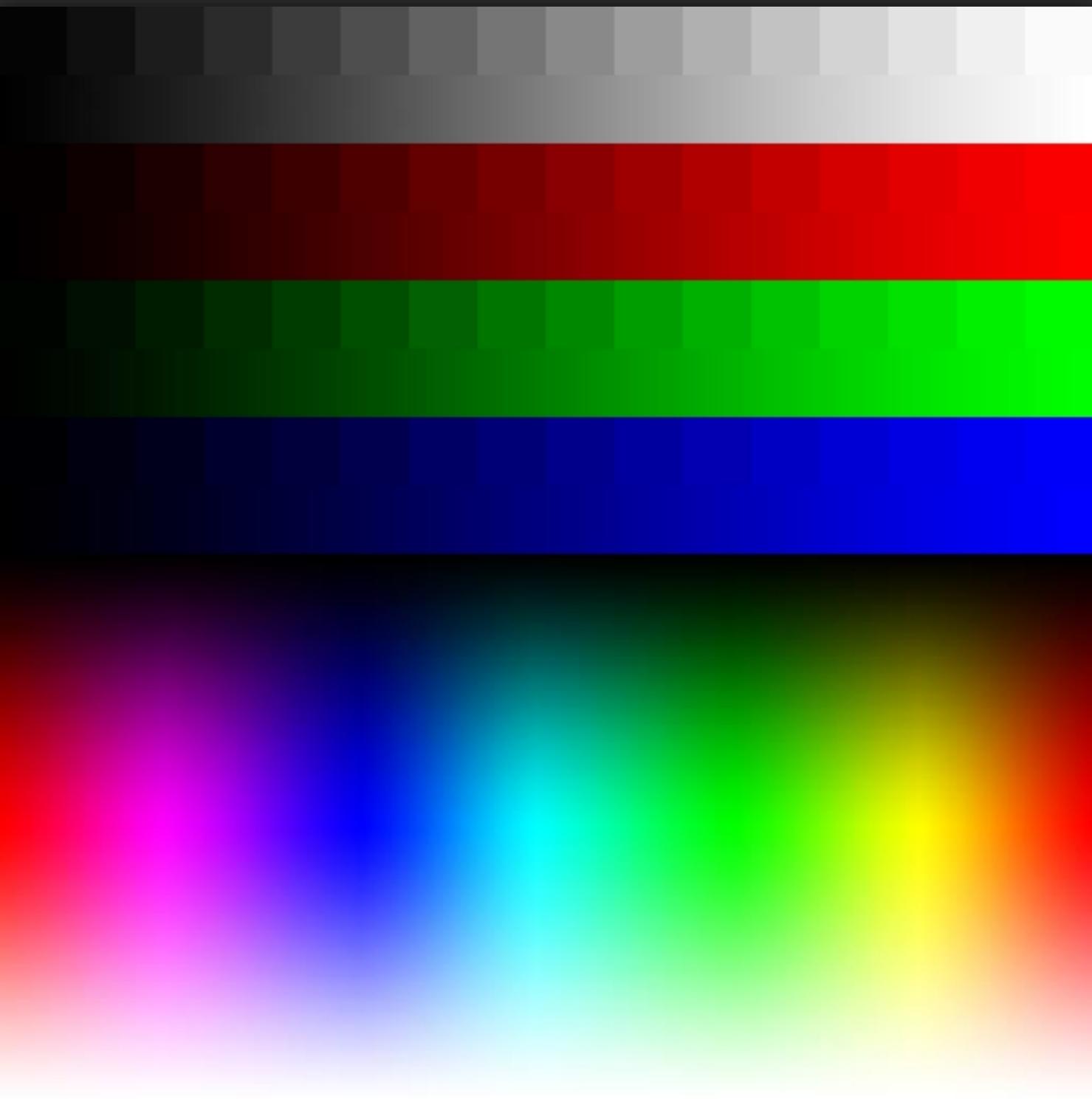
# LIGHTING CALIBRATION \ COLOR CHART

## Gamma chart and gradient chart

Control lighting influence on the textures

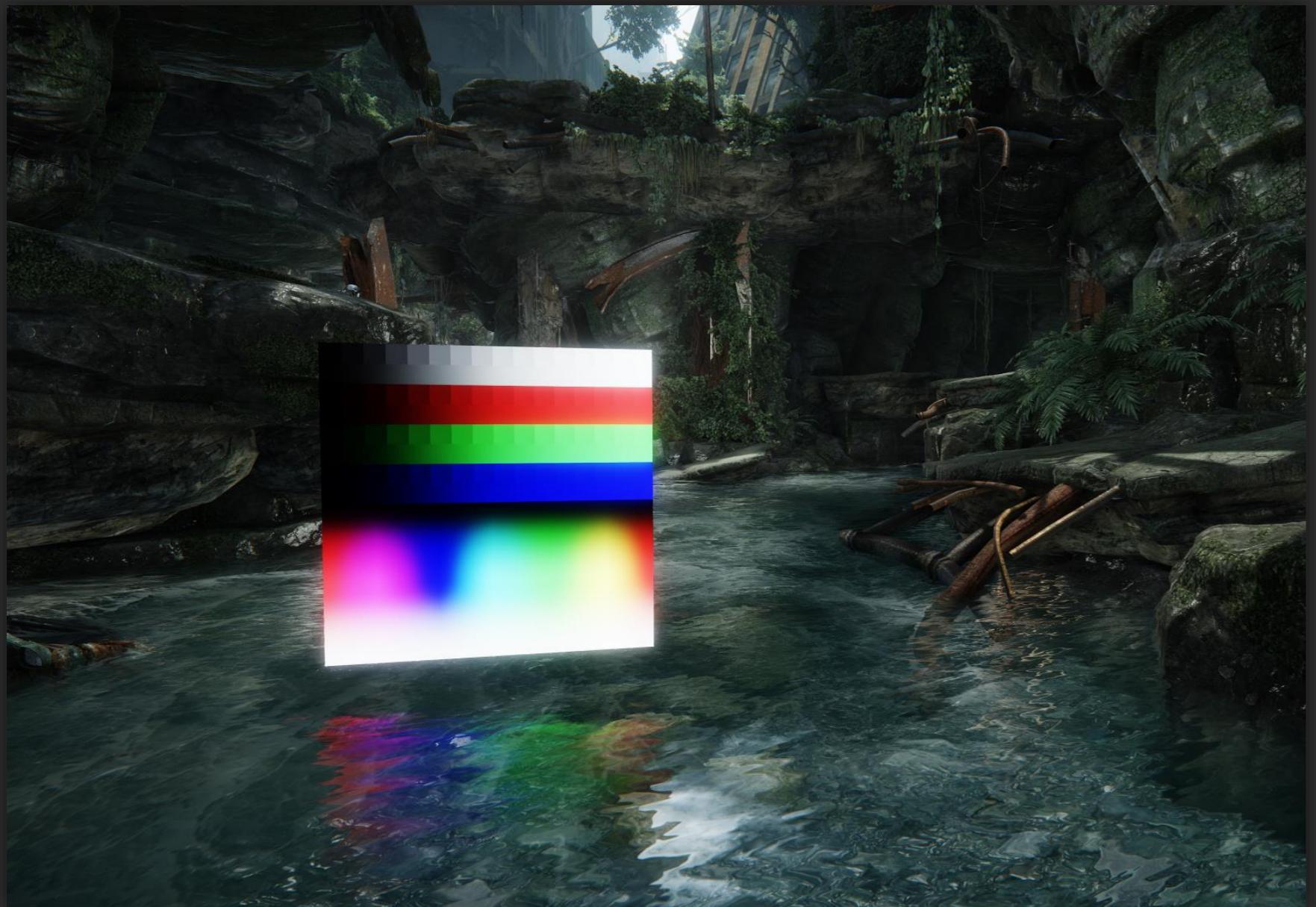
Check post FX influence on the colors and white balance

Prevent clipping of the blacks and whites



# LIGHTING CALIBRATION \ PRACTICAL EXAMPLES

Color chart and reference materials used for calibration and proof checking of the lighting



# PRE-PRODUCTION GUIDELINES

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Did we actually follow all these guidelines?

Diffuse textures?

Yes, although some textures still have too much AO and dark outlines

Physically-based specular textures?

Not really, mix of incorrect specular colors, specular textures and fresnel settings

However, the final result is in the correct range after the light pass/tweaking

Glossiness textures?

Yes

Asset zoo?

Yes, but artists often forgot to store their assets in the level

Lighting calibration?

Yes, although strong clipping is sometimes necessary to achieve a certain look

# CONSOLE LIMITATIONS

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Make the best experience within console limitations

Video and system memory limitations for level size and amount of entities

Optimization of system memory usage for animations, entities, etc.

## Geometries

More aggressive LOD on console

Lower view distance on console

Maximum view and LOD distance on PC

## Textures

Low resolution on console (256px/512px)

High resolution on PC (1024px and above)

# CONSOLE LIMITATIONS

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## Materials

Console-specific materials with less complex shader settings (blend layers, parallax occlusion mapping, etc.)

## Lighting

Limited amount of lights casting shadows on console

Bounce lights usually disabled on console

Maximum lighting quality on PC (shadows and bounce lighting festival)

# FULL PRODUCTION

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## Main titles for environment creation

Level designer: mission owner, scripts implementation, asset placement

Environment/level artist: asset creation, asset placement, terrain and vegetation painting and level beautification

Lighting and FX artists

Cinematic designer

## Group-based production

1 level designer and 2 to 3 artists per level

FX/lighting/beautification artists working on all levels

# FULL PRODUCTION

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## Level production

All levels in production at the same time

“Gameplay pit”, “art pit” and “optimization pit”: focus phases of 1 to 2 weeks for every level

No post-production (lighting and FX on time)

## Advantages

Environment artists assigned to one level only (in theory)

Better communication within the groups

More consistent asset quality due to the limited amount of artists per level

Better optimization due to asset sharing

## Disadvantages

Slow progress

Everything comes together at the end only

# ENVIRONMENTS

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## 7 main environments

Strong variety for locations, lighting and mood

Unique but short experience (6-8 hours of gameplay)

# ENVIRONMENTS \ DOME (JAILBREAK)

## Location

West Side

Outside the dome

## Lighting & mood

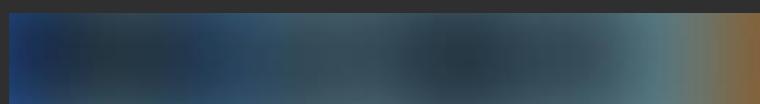
Night

Sunrise

Stormy weather

Intense artificial lighting

## Palette



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# ENVIRONMENTS\FIELDS

## Location

West Side (Penn Station)

High grass fields

Train yard

Train warehouse

## Lighting & mood

Sunny morning

Dark tunnels

## Palette



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# ENVIRONMENTS \ CANYON

Location

Financial District

Canyon

Dam

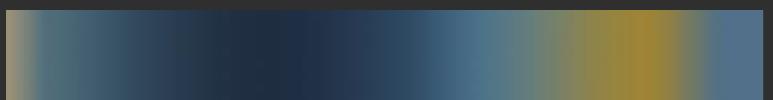
Power station

Lighting & mood

Cloudy afternoon

Dark canyons

Palette





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# CRYYSIS 3



# ENVIRONMENTS \ SWAMP

## Location

Chinatown

Swamp

Abandoned lab

## Lighting & mood

Misty night

Search lights

Mobile lights

Emergency lighting

## Palette



# CRYYSIS 3



# ENVIRONMENTS\RIVER I

## Location

East Side

Dense jungle

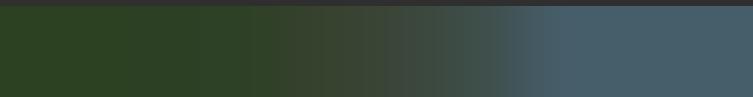
Rivers

## Lighting & mood

Cloudy morning

Dark jungle

## Palette



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# ENVIRONMENTS\RIVER II

## Location

East River

Dry river bed

Warzone

## Lighting & mood

Cloudy morning

Sky in fire

## Palette



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# ENVIRONMENTS \ ISLANDS

## Location

Columbus Circle

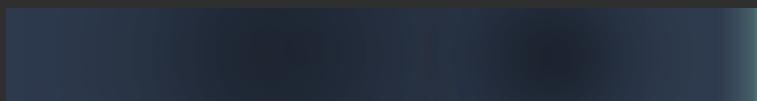
Apocalyptic world

Huge sandbox level

## Lighting & mood

Dark stormy afternoon

## Palette



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# ENVIRONMENTS\CAVE

## Location

Collapsed ruins

Natural caves

Alien structures

## Lighting & mood

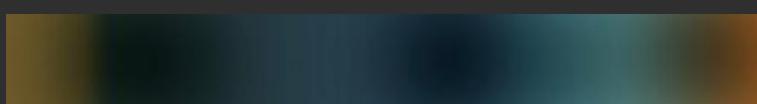
Dusty environment

Dark caves

Natural lighting

Alien lighting

## Palette



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# CHARACTERS \ PIPELINE IN A NUTSHELL

Concepts of the characters

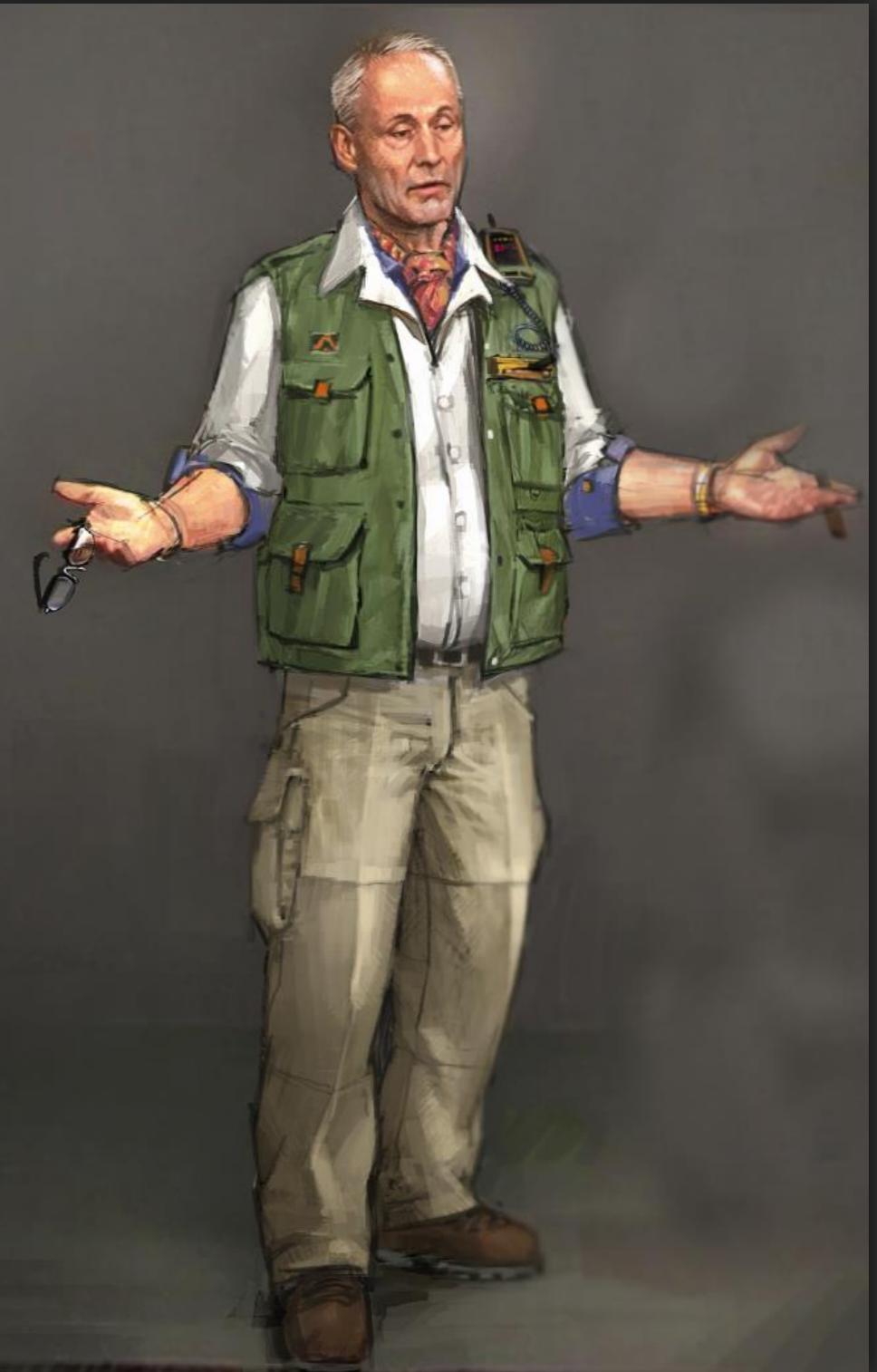
Casting of real actors

Capture of selected actors

3D face scan

Motion capture (body and facial animations)

Voice acting

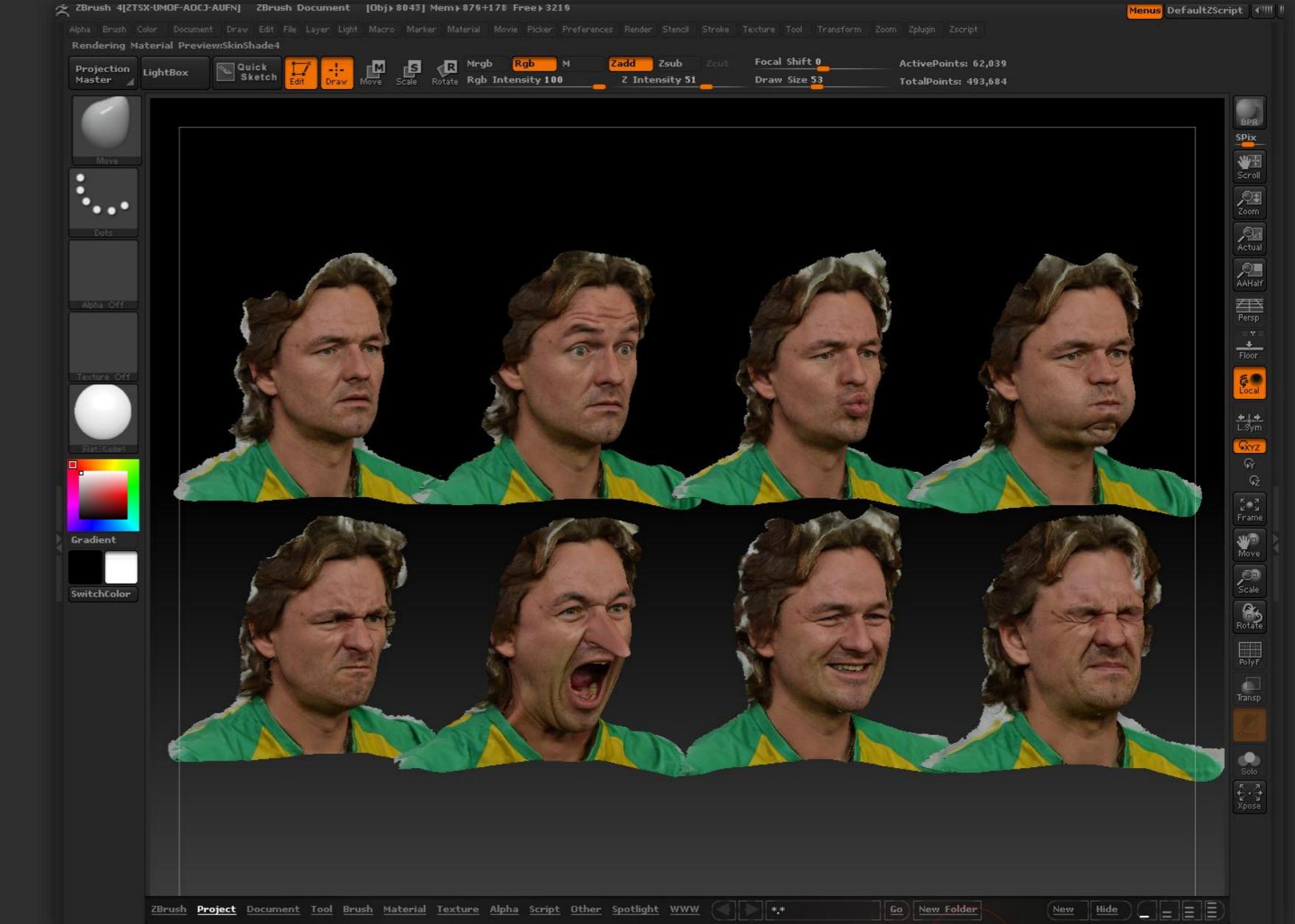


# CHARACTERS \ 3D FACE SCAN

Scan faces with multiple cameras to create a 3D textured geometry



Scanning rig



Results in ZBrush

# CHARACTERS \ MOTION CAPTURE

Body and facial animations and voice acting captured at once



Motion capture session



Final in-game result



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# SKY AND CLOUDS RENDERING

## Technologies

Procedural HDR skybox

Rotating HDR clouds hemispheres

Cloud shadows

## Dynamism

No more old school static painted skyboxes

Moving clouds

Moving cloud shadows



Time-lapse video of clouds hemispheres rotation

# SKY AND CLOUDS RENDERING\VIDEO



# RENDERING TECHNOLOGY \ OVERVIEW

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## Hybrid deferred rendering

Dynamic lighting and shadows, contact shadows for every light source

Localized image-based lighting + Screen Space Reflections

## Vast feature set

e.g. participating media, terrain, characters, vegetation, water, particles, decals, flares, color correction

## High dynamic range rendering

## Antialiasing

## Scalability across different hardware/platforms

Most techniques multiplatform friendly: minimize QA/testing effort

4 quality levels: low, medium, high, very high

# HYBRID DEFERRED RENDERING\THIN G-BUFFER 2.0

Channels				Format
Depth		AmbID, Decals		D24S8
N.x	N.y	Gloss, Zsign	Translucency	A8B8G8R8
Albedo Y	Albedo Cb,Cr	Specular Y	Per-Project	A8B8G8R8

# HYBRID DEFERRED RENDERING\THIN G-BUFFER 2.0



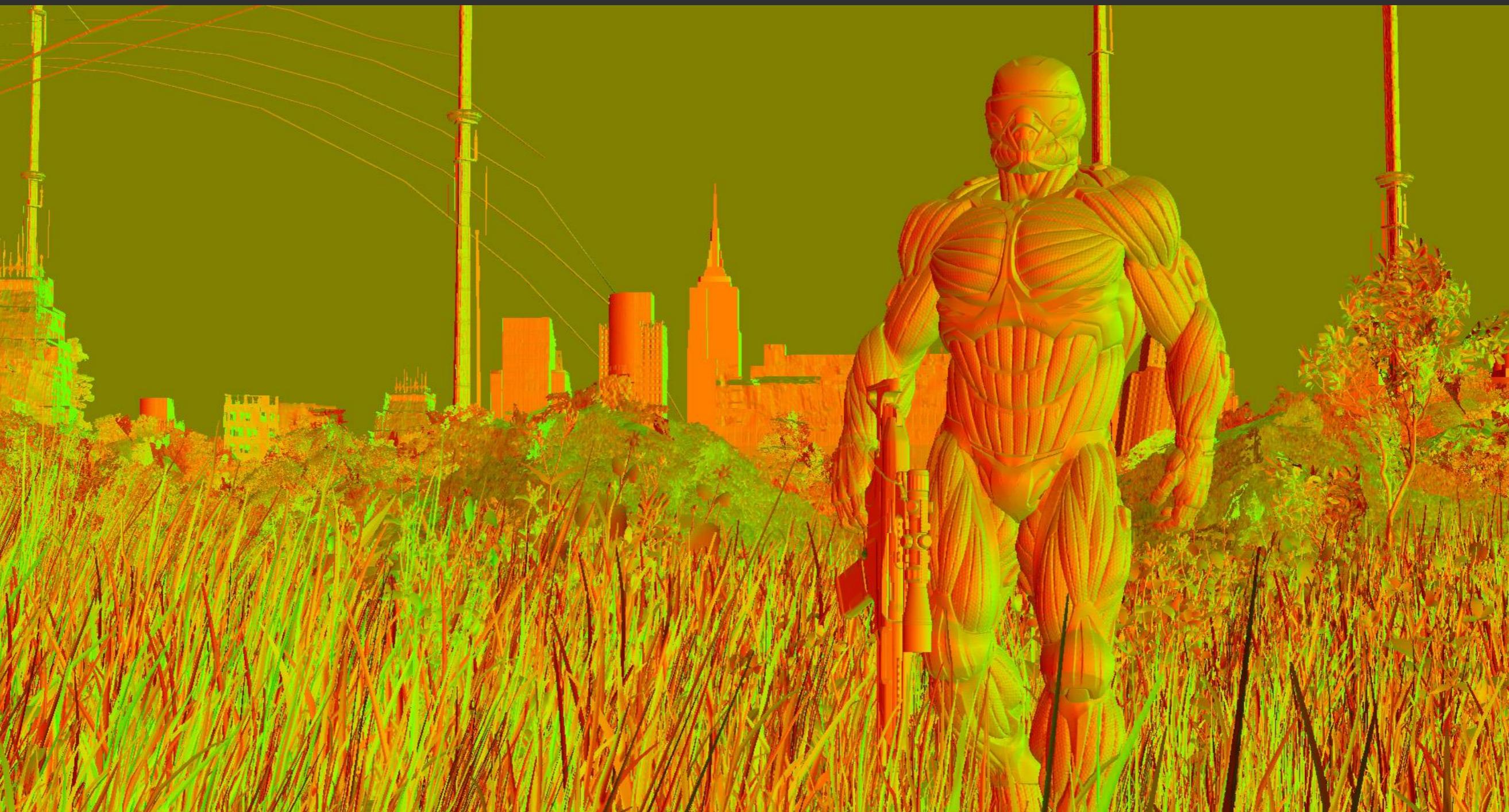
Final Composite

# HYBRID DEFERRED RENDERING\THIN G-BUFFER 2.0



Depth

# HYBRID DEFERRED RENDERING\THIN G-BUFFER 2.0



RG: Normals

# HYBRID DEFERRED RENDERING\THIN G-BUFFER 2.0



B: Glossiness

# HYBRID DEFERRED RENDERING\THIN G-BUFFER 2.0



A: Translucency

# HYBRID DEFERRED RENDERING\THIN G-BUFFER 2.0



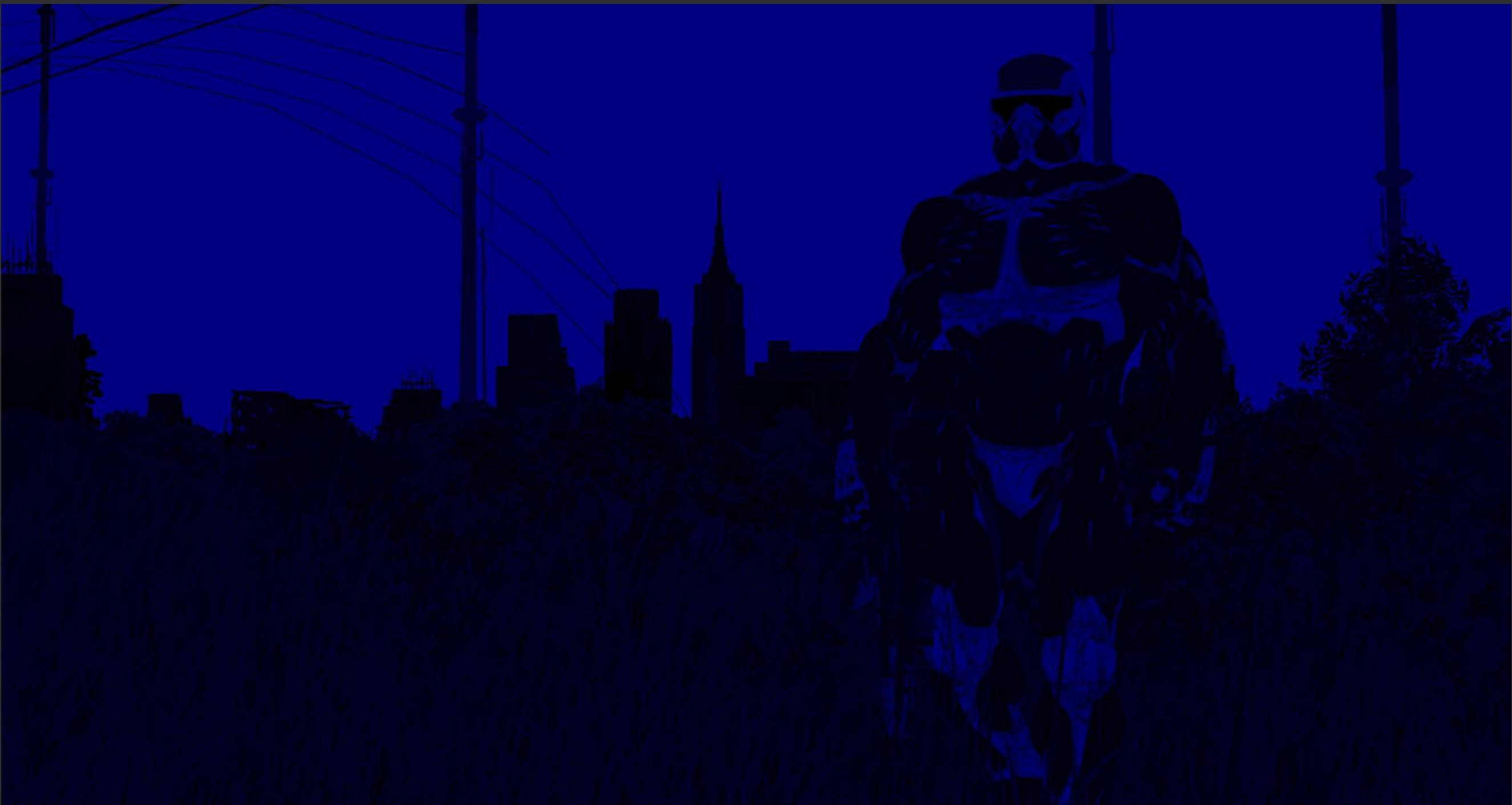
R: Albedo Y

# HYBRID DEFERRED RENDERING\THIN G-BUFFER 2.0



G: Albedo CbCr (interleaved)

# HYBRID DEFERRED RENDERING\THIN G-BUFFER 2.0



B: Specular Intensity

# HYBRID DEFERRED RENDERING\G-BUFFER PACKING I

World space normal packed into 2 components (WIKI00)

Stereographic projection worked well in practice and is fairly cheap

$$(X, Y) = \left( \frac{x}{1-z}, \frac{y}{1-z} \right) \quad (x, y, z) = \left( \frac{2X}{1+X^2+Y^2}, \frac{2Y}{1+X^2+Y^2}, \frac{-1+X^2+Y^2}{1+X^2+Y^2} \right)$$

Glossiness + Normal Z sign packed together

$$GlossZsign = (Gloss \times Zsign) \times 0.5 + 0.5$$

# HYBRID DEFERRED RENDERING \ G-BUFFER PACKING II

Albedo in Y'CbCr color space (WIKI01)

$$Y' = 0.299 \times R + 0.587 \times G + 0.114 \times B$$

$$C_B = 0.5 + (-0.168 \times R - 0.331 \times G + 0.5 \times B)$$

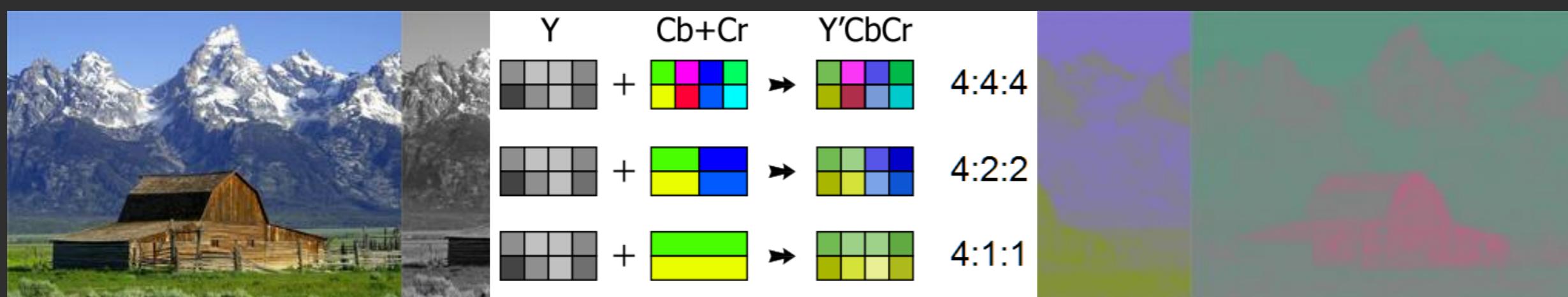
$$C_R = 0.5 + (0.5 \times R - 0.418 \times G - 0.081 \times B)$$

$$R = Y' + 1.402 \times (C_R - 0.5)$$

$$G = Y' - 0.344 \times (C_B - 0.5) - 0.714 \times (C_R - 0.5)$$

$$B = Y' + 1.772 \times (C_B - 0.5)$$

Stored in 2 channels via Chrominance Subsampling (WIKI02)



# HYBRID DEFERRED RENDERING\LIGHTING I

Localized IBL probes+ screen space reflection approximation



# HYBRID DEFERRED RENDERING\LIGHTING II

Artists place probes/sampling locations across levels

Generation of HDR cube maps at desired locations, 32 bits encoded using RGBM

Localized reflection mapping (Bjørke07, Behc10, Lagarde12)

Reflection vector adjusted based on camera location inside probe bounding volume



# HYBRID DEFERRED RENDERING\LIGHTING II

Screen Space Reflection via raymarching along reflection vector (Sousa et.al 11)

Sample depth and check ray depth, if within threshold to scene depth accept sample

Using previous frame + reprojection (encoded using RGBM 32 bits)

Center depth is full resolution, all other taps FP16 half resolution depth

Skip non-glossy surfaces

# HYBRID DEFERRED RENDERING\LIGHTING III

Lights rendered via geometry volume

Sphere for point lights, cone for projectors

Stencil pre-pass, depending on heuristic

Multiplatform friendly

Accumulate light sources into Light-Buffers using MRT (Sousall)

Diffuse and specular contribution into separate targets

Stored in 32 bits fmt (e.g. for PC using R11G11B10F)

Re-using L-Buffers for further passes and techniques

Skin rendering via Screen Space Sub-Surface Scattering

Forward passes using complex shading/composition



# HYBRID DEFERRED RENDERING\SSDO

## Contact Shadows/SSDO (Sousa et.al 11)

Applied to all light sources and ambient, via screen space bent normals (average unoccluded direction)

Center depth is full resolution, all other taps FP16 half resolution depth



SSDO off



SSDO on

# HYBRID DEFERRED RENDERING\SHADING

Deferred shading composited via fullscreen pass

Samples L-Buffers + G-Buffers for composition

More complex shading such as Hair or Skin, processed via forward passes

Allowed dropping almost all opaque forward passes

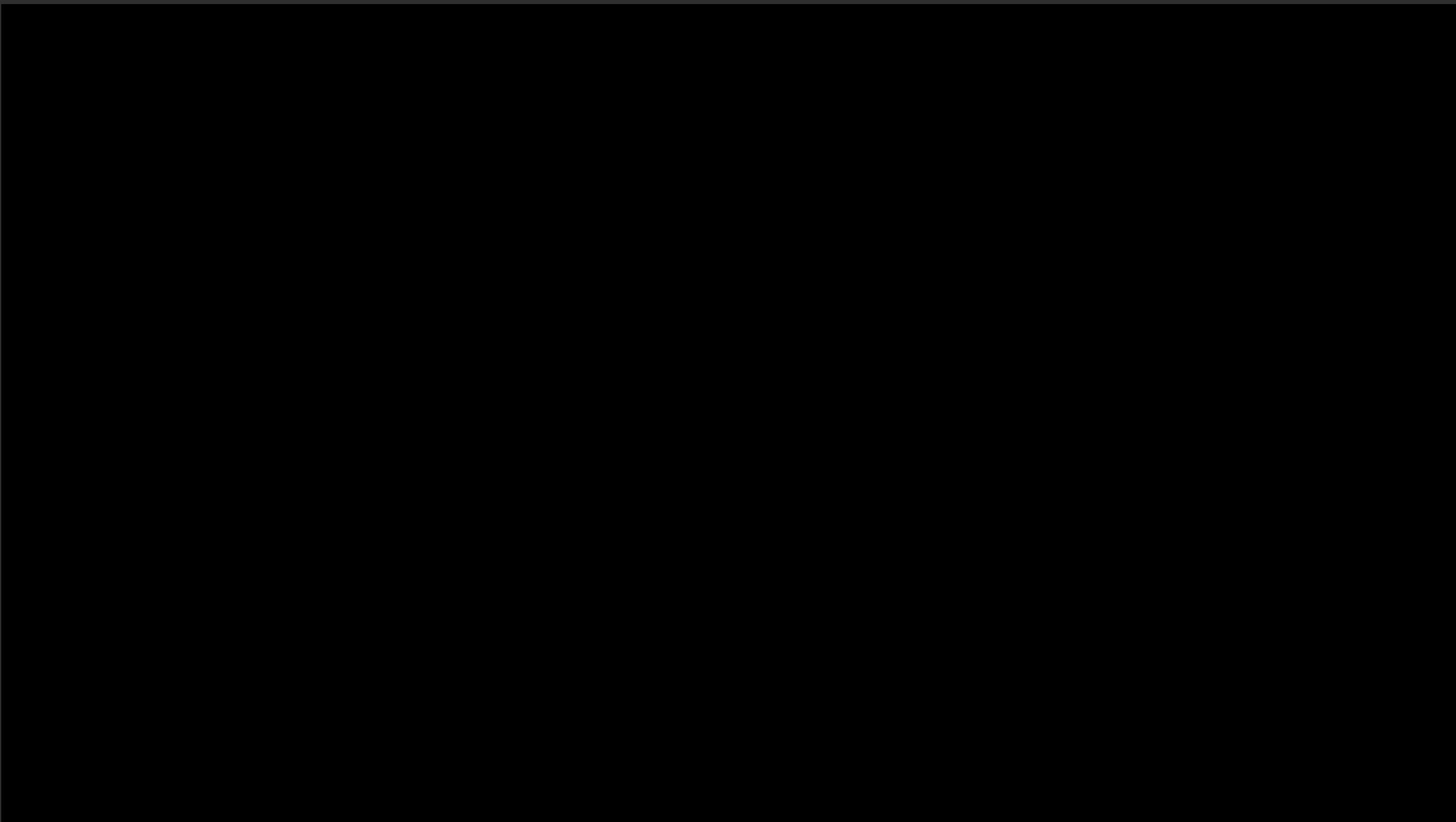


Final results



Deferred (Red) + Forward (Green)

# FEATURE SET \ CRYENGINE 3 2012 HIGHLIGHTS VIDEO



# FEATURE SET\FLARE EDITOR

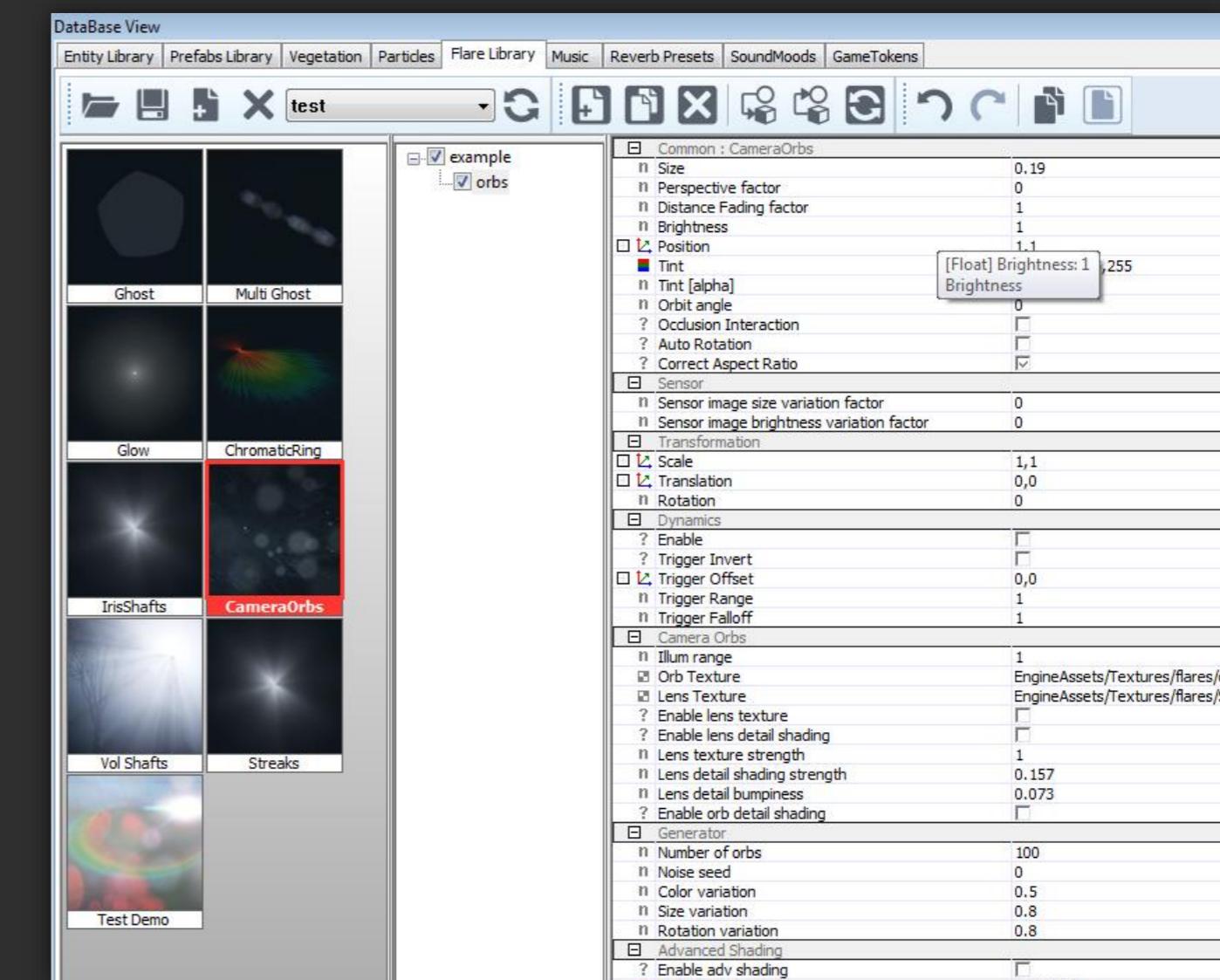
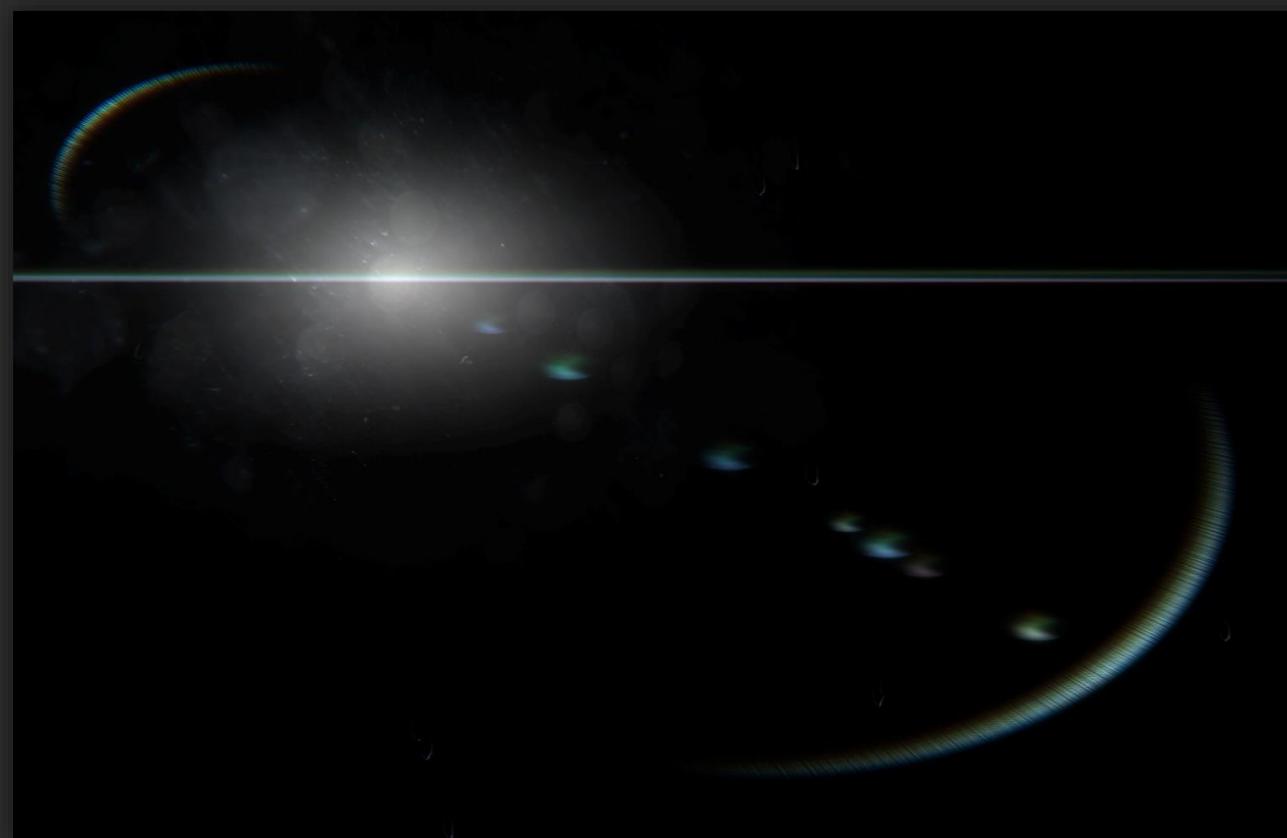
Crysis 2 post process flares suffered a bit from J.J. Abrams syndrome

Partially due to inconsistencies in asset setup (overly bright particles or incorrect material setup)

Flare editor for total artistic control

Not physically-based

Simple 2D sprites composite + multiple flare types

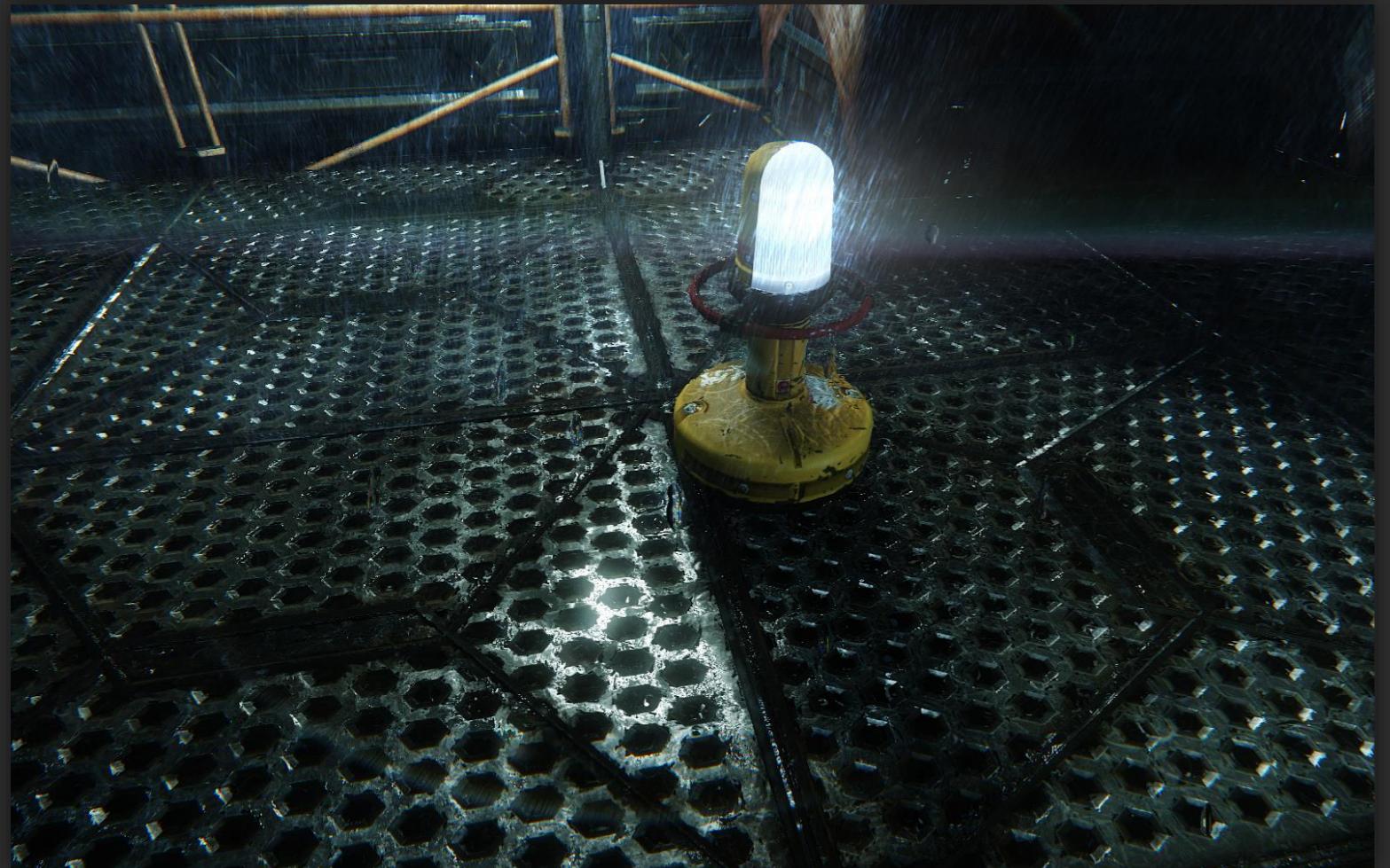


# FEATURE SET \ DEFERRED RAIN I

Introduced in first CryENGINE 3 iteration, tuned further for Crysis 3

Rendered as box volume, using stencil culling/depth bounds

Techniques combo: mist, puddles, rain layers and water drops, fast screen space reflection approximation



# FEATURE SET \ DEFERRED RAIN II

Water puddles: world space, top down projection for texturing, via animated texture

Console friendly screen space reflection approximation

Vertical blur, no depth masking (visually sufficient)

Rain layers: multiple cones centered at camera origin

Snap to new location if camera distance > threshold

Translating rain texture uvs, down rain cones

Bonus trick: approximate rain light scattering, via bloom source



# FEATURE SET \ VOLUMETRIC FOG SHADOWS I

Based on TOTH09

Don't accumulate in-scattered light, instead accumulate shadow contribution along view ray



# FEATURE SET \ VOLUMETRIC FOG SHADOWS II

Interleave pass distributes 1024 shadow samples on a 8x8 grid shared by neighboring pixels

Half resolution destination target

Gather pass computes final shadow value

Bilateral filtering was used to minimize ghosting and halos

Shadow stored in alpha, 8 bit depth in red channel

Used 8 taps to compare against center full resolution depth

Max sample distance configurable ( $\sim 150\text{-}200m$  in C3 levels)

Cloud shadow texture baked into final result

Final result modifies fog height and radial color

## FEATURE SET \ VOLUMETRIC FOG SHADOWS III

Naive upscale



# FEATURE SET \ VOLUMETRIC FOG SHADOWS IV

Bilateral Upscale



# HIGH DYNAMIC RANGE RENDERING \ OVERVIEW

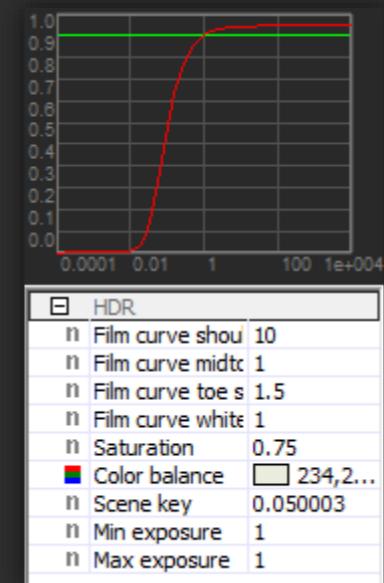
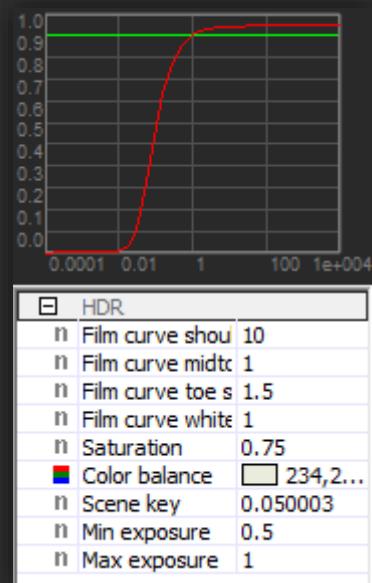
Linear correct on all platforms (Gritz07, Sousa11)

e.g. lighting, texture filtering, blending, motion blur, depth of field and antialiasing

Switched to film tone mapping (Hable2010)

Several schemes tested for automated exposure/key (e.g Reinhard02, Krawczyk05)

Simple solution chosen: let art fine tune (curve, scene key, min and max exposure for eye adaption)



# ANTIALIASING \ OVERVIEW

Support for latest and greatest antialiasing modes: FXAA, Deferred MSAA, SMAA & TXAA

Subjective topic: some users like sharper image, others softer image

Each mode has its strengths/user preferences

FXAA is the fastest mode of the pack

Deferred MSAA is the vanilla standard and foundation work for SMAA and TXAA to work at all

SMAA aims at a razor sharp results with reasonable temporal stability

TXAA aims at a more cinematic/softer looking image with high temporal stability

SMAA/TXAA a smart combo

MSAA + SSAA via previous frame sub sample reprojection + morphological (post-process) antialiasing

See Siggraph 2011 AA course [Jimenez Et.Al 11] and our GDC 2013 talk for details [Sousa Et.al. 13]





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# REMINDER

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We are hiring!

<http://www.crytek.com/career>

# QUESTIONS?

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